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Explanation of stock price behavior by computer-aided content analysis

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Nr. 72

Explanation of Stock Price Behavior
by Computer-Aided Content Analysis

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and

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1. Introduction *)

Empirical investigations of stock price behavior can be classified into two classes. Firstly, there are investigations only using the stock prices themselves without looking at explaining variables. Such studies aim at the underlying statistical distribution and at the efficiency of various trading policies. Secondly, there exist investigations which try to get results on the information content of stock prices and on the processing of information at the stock exchange. In these studies the authors restrict themselves by investigating only one influence factor, e.g.

- Beaver (1968): earnings information
- Fama, Fisher, Jensen, and Roll (1969): stock splits
- Niederhoffer (1971): world events
- May (1971): quarterly earnings announcements
- Foster (1973): estimates of earnings per share
- Altman and Brenner (1976): signs of firm deterioration
- Nichols and Tsay (1979): executive earnings forecasts.

The isolated investigation of such influence factors is advisable because of the methodological problems associated with a simultaneous investigation of several influence factors. But it is a disadvantage of such a procedure that the results are of little importance to the aspired practical forecasting of stock prices. Thus there is a need for a methodological approach which can handle several influence factors simultaneously.

The theoretical basis of such a new approach may be found in the paper of Boness and Jen (1970). The authors there develop a model of stock price formation with respect to new information. The importance of new information of kind k relevant to the value of stock j occurring in period t (ibid. p. 283) is considered; factors representing the perception and interpretation of information of kind k for trader i with respect to stock j are introduced (ibid.).

*) The authors are indebted to Pål E. Korsvold and Hans Joachim Stemann for useful comments.

A methodological instrument of applying the Boness and Jen approach may be content analysis, a method having been applied by social scientists in numerous cases. In the following we shall use computer-aided content analysis to explain stock price behavior.

The procedure will be as follows. Under the hypothesis that news - disseminated by newspapers - are relevant informations with respect to stock price formation, we at first describe the process of content analysis and present some results. Then we establish the model of news-dependent stock price formation. The model is tested by stepwise multiple regressions of stock price indices against the variables produced by the previously done content analysis. It is demonstrated that content analysis can be a useful instrument to explain stock price behavior in case of several influence factors.

2. Content Analysis of Newspaper Headlines for Stock Price Explanation

The use of content analysis allows a lot of empirical research designs [see Schmidt (1979) for this]. In the following we describe the collection of data and the use of a program package for content analysis which has been developed by Ahrens (1978) at the University of Kiel. Because of the voluminous output we only present some statistics.

2.1 Data Collection

The selection of information source plays an important role for the subsequent content analysis because the results of this method depend upon the adequate sources heavily. It is hypothesized that investors buying and selling stocks at the stock exchange refer to newspapers as a source of information. The selection of adequate newspapers should be based upon national importance. Under these requirements two German

newspapers were chosen: the "Frankfurter Allgemeine Zeitung" (FAZ) and a special economic newspaper, the "Handelsblatt" (HB). Two newspapers were taken because of the willingness to study possible differences between newspapers.

In opposition to existing studies on stock price behavior we did not select any kind of special information. On the contrary, all headlines (not commentaries) and all sentences (been printed by heavy type) were taken as input data - with the restriction of two pages per newspaper. The two pages of each newspaper have a special content so that four data sets were established (see Table 1).

Table 1:
Selected newspaper headlines

Set of explaining variables	Type of news	Source of investigated headlines
I	General news	"Frankfurter Allgemeine Zeitung", page one
II	Economic news	"Frankfurter Allgemeine Zeitung", first page of economic part
III	Economic news	"Handelsblatt", page one
IV	News on securities markets	"Handelsblatt", first page on securities markets

While data set I contains general news - perhaps irrelevant to the stock market -, the data sets II and III represent the main economic facts that should influence stock prices more than the data of set I. The data set IV is interesting with respect to stock price behavior because the "news" are reports on the securities markets of the previous day. Thus it is possible to test the influence of past events on stock prices.

Data were collected for all editions of the two newspapers from October 9, 1978 to December 2, 1978 (eight weeks).

The choice of the period was due to the fact that data on stock prices were already available for that period from another research project. Table 2 gives some insight into the data material. All data belonging to the same data set and the same day of edition were defined as one "document".

Table 2:
Characteristics of news data

Data set	Number of sentences	Total number of words	Trivial words	Words for classification
I (FAZ)	794	4118	1453	2665
II (FAZ)	897	3903	1299	2604
III (HB)	344	3920	1798	2122
IV (HB)	193	2532	1276	1256
Total	2228	14473	5826	8647

Table 2 shows that the number of words which shall be investigated can be diminished by introducing a category "trivial words". Nevertheless, the number of words to be classified with respect to their contents remains great: the work cannot be done without computer aid.

2.2 Content Analysis

It was decided to perform the content analysis on a one-word basis - though better results should come out by coding whole sentences rather than single words [see the examples at Schmidt(1979)]. One-word basis means that each of the non-trivial words - the frequency of which exceeding a certain number - is presented on the computer terminal and must be assigned to a category of content. To do this, the scheme of categories must be defined before.

This classification scheme of words with respect to their contents depends upon the investigated problem. Thus, the scheme should be related to stock price formation here. Table 3 presents a comprehensive version of the group of variables and the further specifications of these variables.

Table 3:
Specification of explaining variables

Type of category	Specifications
General valuation	very good, good, neutral, bad, very bad
General politics	good, neutral, bad
General economic policy	good, neutral, bad
Business cycle	good, neutral, bad
Money and credit	good, neutral, bad
Securities market	good, neutral, bad
Industry	MOTO, BANK, CHEM, ELEC, DEPA, MECH, IRON, TEXT, TRAF, OTHE

The category "general valuation" allows for words which are pure valuations while the next five groups of categories are related to areas being more or less connected with stock prices. The specifications of the seven groups of categories in Table 3 add up to 30 variables. Further categories - e.g. a category "not classified" - were established; they are not reported in Table 3 because most of them are reserved for an analysis of single stocks, not indices.

The material of Table 2 was classified with respect to the defined categories whereby all words which appeared only once in all the data were dropped. The words were classified by one of the authors; the other author then revised the assignment of categories. A processing of words by more people would

be desirable [see for this procedure Niederhoffer (1971)], but was not possible at present.

The procedure of classification could also be widened: then the meaning for a special stock (index) and for a special group of stockholders should be evaluated.

As an example of classification, Table 4 presents some data out of the general valuation categories "bad" and "good".

Table 4:
Examples of classified words
- categories "good" and "bad" -

Category "good"		Category "bad"	
ANHALTENDE	2	ABWAERTSBEWEGUNG	4
AUSGEPRAEGTEN	2	BEFUERCHTET	4
BESSERE	2	BROECKELTEN	4
DURCHBRUCH	2	DRUCK	4
ERFOLGREICH	2	ENTTAEUSCHT	4
ERHOEHEN	2	FAELLT	4
ERHOLT	2	FIEL	4
ERLEICHTERUNGEN	2	FURCHT	4
FREUNDLICH	2	GEFAHR	4
GROESSERE	2	GERINGE	4
GROSSEM	2	HART	4
GUT	2	KAUM	4
GUTER	2	KLEINERE	4
HOENER	2	KORRIGIERT	4
HOEHERER	2	KURSVERLUSTE	4
LEBHAFTER	2	MASSIVEN	4
NEUE	2	NERVOES	4
OPTIMISMUS	2	RUECKSCHLAG	4
PLUS	2	SCHARFE	4
SCHNELL	2	SCHWACH	4
STIEG	2	SCHWAECHEER	4
STABILER	2	SCHWERER	4
STAERKER	2	SCHWIERIGKEITEN	4
STEIFEN	2	SORGE	4
VERBESSERT	2	TIEF	4
VERDREIFACHT	2	UNFREUNDLICH	4
VERSTAERKTEN	2	UNSICHERHEIT	4
WACHSENDE	2	VERRINGERT	4
ZUWACHS	2	ZURUECK	4
		ZURUECKGETRETEN	4

Table 5 contains information about the absolute frequencies within the various categories. It can be seen that "good" and "bad" news are represented by a remarkable number of words. Table 5 also shows that the classification of the words worked well (data set I consists of many words out of the category "general politics", while data set IV represents the category "securities market", in deed).

Table 5:
Absolute frequencies of classified words

Category		Data set			
		I	II	III	IV
General valuation	- very good	0	19	8	4
	- good	51	138	72	72
	- neutral	26	72	51	86
	- bad	54	93	37	85
	- very bad	8	8	9	3
General politics	- good	87	34	27	6
	- neutral	825	371	286	73
	- bad	150	65	48	6
General economic policy	- good	19	25	18	0
	- neutral	18	74	59	10
	- bad	4	14	10	0
Business cycle	- good	5	12	4	0
	- neutral	32	126	80	32
	- bad	3	20	9	0
money and credit	- good	1	1	2	0
	- neutral	1	25	17	7
	- bad	1	3	4	0
Securities market	- good	0	3	4	12
	- neutral	2	24	28	256
	- bad	1	0	1	2
Industries	- MUTU	1	12	2	0
	- BANK	0	0	0	3
	- CHEM	1	1	0	0
	- ELEC	0	3	3	0
	- DEPA	0	6	0	7
	- MECH	0	0	0	10
	- IRON	31	35	39	4
	- TEXT	0	0	2	0
	- TRAF	0	4	1	0
	- OTHE	8	28	30	1
Total frequency		1406	1213	851	679

The absolute frequencies being reported in Table 5 can be changed into relative frequencies (with respect to the number of words in a given document). These relative frequencies will be used as explaining variables of stock price behavior. The variables were standardized (with zero mean and standard deviation one).

3. Explanation of Stock Price Behavior

3.1 The Model

It is assumed that stock prices depend upon several Types of news. The relationship between stock prices and news shall be formulated for the absolute stock price index or for the relative change of the index. For the latter case we formulate:

$$(1) \quad \frac{P(j,t)}{P(j,t-1)} = a(j) + \sum_{k=1}^K b(j,k) \cdot I(k,t+J) + e_j$$

with $P(j,t)$ - stock price index of industry
j on day t

$a(j)$ - parameter to be estimated

$I(k,t+J)$ - relative frequency of news of
type k in the newspaper on day
t+J

$b(j,k)$ - parameter to be estimated

e_j - error term

In case of absolute prices we formulate:

$$(2) \quad P(j,t) = A(j) + \sum_{k=1}^K B(j,k) \cdot I(k,t+J) + E_j$$

The parameter \mathcal{J} in (1) and (2) takes into account the processing of information: If $\mathcal{J}=0$, the news published on day t influence the stock prices of the same day. The correctness of this specification depends upon the deadline of the newspaper disseminating the news. This deadline is a certain hour on day before the appearance of the edition. If the stock exchange closes - like in Germany - at 1.30 p.m. and the deadline of the newspaper is at 4 p.m., then most of new information could be processed by the stock exchange on the day before the appearance of the newspaper edition. In such a case best results should come out for $\mathcal{J}=1$.

Whether new information is processed by the stock exchange before the appearance of the newspaper edition, this is a problem of insider trading, of the "ticker" quality, and of the "news" producing ability of the newspaper. It may be that the newspaper produces "new" (own) information. Thus the variation of \mathcal{J} in (1) and (2) may give some hints on the nature of information processing.

At present, we do not formulate (1) and (2) on the basis of residuals derived from regressions with the market index [see Fama et al. (1969)]: we are investigating indices, not stocks.

3.2 Stock Price Data

Equations (1) and (2) are formulated for stock price indices; we used index data derived from single stock prices. The names of 60 broadly traded German stocks were taken from a list in "Wirtschaftswoche Special: Ihr Geld '79" (October 1978) - at that time published for purposes of a stock investment game. One stock was omitted to get a round figure of stocks - it was the only stock with prices above 1000 DM. The daily stock prices of the Düsseldorf stock exchange were collected by the Westdeutsche Landesbank Girozentrale and transmitted to the authors. The data covered the period from October, 6 to December, 27 (1978).

The raw data were completed for those trading days with zero volume for a specific stock; in such a case the stock price of the last trading day with a positive volume was assumed to represent the missing value. The number of such corrections was small.

44 stocks then were assigned to nine industries (see the abbreviations of these industries in the last row of Table 3). 16 stocks could not be assigned to these industries. On the average five stocks were used to construct an industry index. The general index of 60 stock prices and the nine industry indices were computed as weighted averages - the share capital being the weight. Because the 60 firms did not change their capital figures within the investigated period, we did not divide the daily market values by the market values at the beginning of the period. Thus, our indices used in eq. (2) represent the market values for each industry.

The investigation period of content analysis (see above) ran from October, 9 (Monday) to December, 2 (Saturday) in 1978. Thus, we had to compute the index values [eq. (2)] and the relative index changes [eq. (1)] for the same period, but taking into account two stock exchange holidays at the Düsseldorf stock exchange. This led to 38 observations, to be explained by the variables of content analysis.

3.3 Results of Multiple Regressions

To test equations (1) and (2) stepwise multiple regressions were performed for the following designs:

1. one general index and nine industry indices to be explained (dependent variables);
2. type of equation (1) or (2) [eq. (1) being a model of reaction to news, eq. (2) being a model of stock (index) valuation by news];
3. newspapers FAZ and HB;
4. data sets I, II, and I + II (for FAZ) and data sets III, IV, and III + IV (for HB) [explaining variables];

5. indicator of lead (\mathcal{J}) equal to zero or one;
a lead of zero means that the news published on day t influence the stock prices of this day t . A lead of one assumes that the stock market gets the news before they are published by the newspapers.

All together $10 \cdot 2 \cdot 2 \cdot 3 \cdot 2 = 240$ stepwise multiple regressions were performed using a modified version of the IBM-SSP package STEPRG. The results confirm the approach of (computer-aided) content analysis for the explanation of stock price behavior.

In Table 6 results for eq. (1) are presented [data set I of FAZ with zero lead].

The results of Table 6 show a significant influence of general politics on relative stock price changes. In 6 out of 10 multiple regression results, negativ news about general politics are coming into the regression as explaining variables at first. Because of the standardization of explaining variables, the intercept equals the mean of the dependent variable. Though the influence of general politics is significant, its magnitude does not exceed 0,4 % per daily change in 68 % of all cases (if we assume normality of the information distribution).

Further results on relativ index changes shall not be reported here. Instead of this we concentrate on the investigation of eq. (2). Results of 120 runs - in the form of multiple correlation coefficients (adjusted for degrees of freedom) - are reported in Tables 7 and 8. The results belong to (multiple) regressions where all the regression coefficients are significant at the 0.05-level.

Table 6:
Regression results: relative index changes
explained by news of page one of FAZ

Industry	Intercept	Slope	Name of variable	(Multiple) corr. coeff.
General index	0.99920	- 0.00241 (0.00110)	GPOL -	0.334 *
Motor vehicles	0.99922	- 0.00206 (0.00112)	GPOL -	0.294
Banking	0.99958	- 0.00242 (0.00104)	GPOL -	0.361 *
Chemicals	0.99902	+ 0.00474 (0.00176)	OTHER	0.450 *
		- 0.00370 (0.00176)	CHEM	
Electricals	0.99868	- 0.00309 (0.00110)	GPOL -	0.492 **
		- 0.00258 (0.00110)	BUSCYC -	
Dep. Stores	0.99866	- 0.00317 (0.00172)	GPOL -	0.294
Mech. Engineering	1.00097	- 0.00350 (0.00143)	GPOL -	0.438 *
		- 0.00323 (0.00143)	BUSCYC -	
Iron and Steel	0.99959	- 0.00376 (0.00143)	GPOL -	0.534 **
		- 0.00444 (0.00161)	BUSCYCØ	
		+ 0.00413 (0.00160)	MONCRE#	
Textiles	0.99850	+ 0.00461 (0.00102)	MOTOR	0.637 **
		- 0.00219 (0.00102)	BUSCYC -	
Traffic	0.99649	+ 0.00550 (0.00212)	MONCRE -	0.447 *

* = level of significance 0.05

** = level of significance 0.01

Table 7:
Correlations between stock price indices
and news published by "Frankfurter Allgemeine Zeitung"
(Multiple correlation coefficients)

Type of stock price index	No lead of stock prices			Lead of stock prices		
	Page one	First page of economic part	Both pages together	Page one	First page of economic part	Both pages together
	(1)	(2)	(3)	(4)	(5)	(6)
General	0.322*	0.730**	0.864**	0.343*	0.362*	0.823**
Motor vehicles	0.282	0.812**	0.891**	0.319	0.568**	0.636**
Banking	0.319	0.738**	0.781**	0.388*	0.325*	0.699**
Chemicals	0.327*	0.708**	0.790**	0.351*	0.312	0.662**
Electricals	0.303	0.604**	0.604**	0.293	0.424**	0.691**
Dep. Stores	0.338*	0.713**	0.815**	0.478**	0.469**	0.478**
Mech. Engineering	0.444	0.643**	0.643**	0.503**	0.461**	0.631**
Iron and Steel	0.294	0.743**	0.849**	0.321*	0.437**	0.711**
Textiles	0.382*	0.669**	0.573**	0.462**	0.272	0.462**
Traffic	0.303	0.539**	0.626**	0.306	0.276	0.306
Mean correlation coefficient	0.331	0.690	0.744	0.376	0.391	0.610

* = level of significance 0.05

** = level of significance 0.01

Table 8:
Correlations between stock price indices
and news published by "Handelsblatt"
(multiple correlation coefficients)

Type of stock price index	No lead of stock prices			Lead of stock prices		
	Page one	First page on securities markets	Both pages together	page one	First page on securities markets	Both pages together
	(1)	(2)	(3)	(4)	(5)	(6)
General	0.566**	0.438*	0.790**	0.691**	0.276	0.637**
Motor vehicles	0.669**	0.319	0.753**	0.605**	0.367*	0.821**
Banking	0.787**	0.461**	0.751**	0.683**	0.300	0.727**
Chemicals	0.511**	0.436**	0.606**	0.551**	0.414*	0.749**
Electricals	0.686**	0.308	0.686**	0.664**	0.412*	0.664**
Dep. Stores	0.526**	0.507**	0.526**	0.674**	0.395*	0.789**
Mech.Engineering	0.655**	0.716**	0.704**	0.658**	0.263	0.793**
Iron and Steel	0.619**	0.325*	0.672**	0.628**	0.278	0.821**
Textiles	0.642**	0.460**	0.754**	0.560**	0.377*	0.878**
Traffic	0.396*	0.434*	0.396*	0.731**	0.400*	0.686**
Mean correlation coefficient	0.545	0.440	0.664	0.664	0.645	0.757

* = level of significance 0.05

** = Level of significance 0.01

The results of Tables 7 and 8 can be summarized as follows:

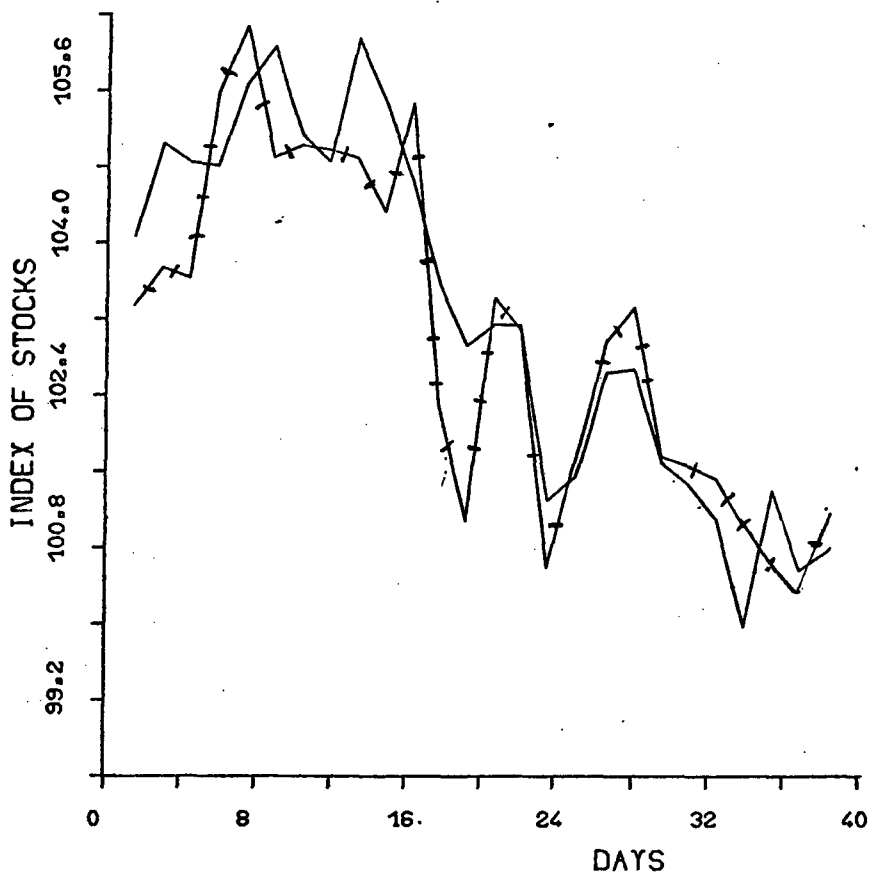
1. The FAZ produces economic news which are processed of the stock exchange after the appearance of the FAZ-edition. This conclusion comes out by comparison of columns 2 and 5 in Table 7.
2. HB's news seem to be processed more on the day before the appearance of the HB-edition (compare col. 1 and 4, and col. 3 and 6 of Table 8). This may be explained by the fact that the publishers of HB are connected with a ticker service.
3. There is a slight tendency that general news - in opposition to economic news - are processed one day before the appearance of a FAZ-edition (compare col. 1 and 4 of Table 7).
4. "News" about the past stock exchange sometimes are processed by the stock-exchange one day later (see col. 2 of Table 8). This result may be a sign of autocorrelation at the German stock exchanges stated elsewhere in the literature. [see Bertoneche, Hecker, Kahnert, Reiß].

All together, the approach of content analysis not only explains information processing at the stock exchange but also may be of some help when estimating the effects of events on stock prices [see Figure 1 for the fit of the regression reported in row 1 and col. 3 of Table 7].

Though the multiple correlation coefficients and the regression coefficients mostly are significant on the 0.05-level, the types of entered variables differ between the various regressions. It can only be stated that the signs of the regression coefficients are plausible from the economic standpoint and that variables of the "good"- and "bad"-categories came in more often than the neutral categories.

Figure 1

General stock price index
and its explanation by content analysis variables



— = Stock price index plot

+ + + = Regression plot.

The importance of bad news as explaining variables may be due to the fact that there was a major decline in stock prices for the investigated period.

A widening of the design could lead to still better results, especially by

- looking only at the changes which exceed some specified level (see Niederhoffer for this approach)
- investigating deviations from a trend
- assuming reaction functions with respect to news
- analyzing the content of sentences, not of single words (see Schmidt for this approach)
- combining the information from several sources (not only newspapers)
- coding the content of news for each dependent variable separately
- changing the functional relationships (perhaps from an additive to a multiplicative version).

For an investigation of single stock prices, it could be advisable to establish an index model of information influences analogous to index models of portfolio theory.

4. Conclusions

The adjustment of stock prices to new information is a problem which has been taken up by the literature several times. All these empirical investigations handle with one isolated influence factor. A content analysis of news published by newspapers makes it possible to get variables for several influence factors. It is shown how such variables can be generated on the basis of a defined scheme of categories.

The relative frequencies of news in the different categories then are used as explaining variables in multiple regressions, in which stock price indices or their relative changes are the dependent variables.

Empirical results - using different data sets - demonstrate that the information processing at the stock exchange can be portrayed and specified by the content analysis approach. Further research should widen the analysis - as stated in the paper -. One should look for numerical estimates of a mixture of events on stock prices.

oOo

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